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Identification of Parasites of the Douglas-fir Tussock Moth, Based on Adults, Cocoons, and Puparia



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U.S. DEPT OF AGRICULTURE
U.S. FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION

Torolf R. Torgersen

PUBLISHED IN COOPERATION WITH THE
USDA DOUGLAS-FIR TUSSOCK MOTH
PROGRAM

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
PORTLAND, OREGON

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Identification of Parasites

of the Douglas-fir Tussock Moth

b[1]b

Based on Adults, Cocoons, and Puparia

[2,3],

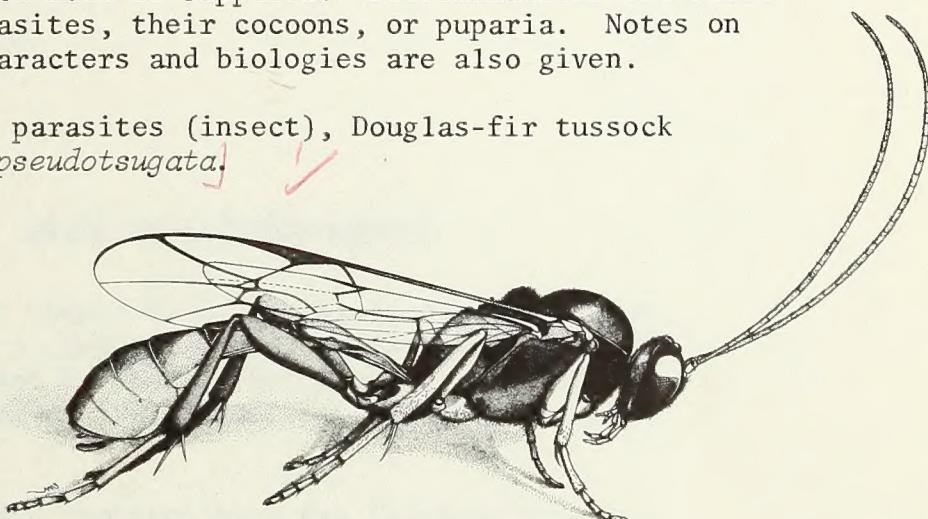
Reference Abstract

Torgersen, Torolf R.

1977. Identification of parasites of the Douglas-fir tussock moth based on adults, cocoons, and puparia. USDA For. Serv. Res. Pap. PNW-215, 28 p., illus. Pacific Northwest Forest and Range Experimental Station, Portland, Oregon.

A key for the identification of egg, larval, and pupal parasites of the Douglas-fir tussock moth is supplied. Determinations are based on features of adult parasites, their cocoons, or puparia. Notes on additional diagnostic characters and biologies are also given.

KEYWORDS: Parasite key, parasites (insect), Douglas-fir tussock moth, *[Orgyia pseudotsugata]*



RESEARCH SUMMARY

Research Paper PNW-215

1977

Since the widespread outbreaks of Douglas-fir tussock moth in the West during the early 1970's, many pest management and university personnel have become involved in rearing this insect. Rearings have been conducted for a variety of purposes, among them the determination of the occurrence of parasitism and the species comprising the parasite complex.

An illustrated key to 30 species of the more common parasites is presented. The key permits identification of both adult parasites and their cocoons or puparia. Supplemental diagnostic descriptions are given to help the user verify determinations. Brief notes on the biology of each species are also included.

कामाक्षी ने गोवर्णनीय
मंत्री जिल्हा राज्यालय के लिए वे
भूमिका ली। अपनी सेवा की बातें

जीवन की अद्भुत विशेषताएँ।

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Acknowledgments

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The research reported here was financed in whole or part by the USDA Expanded Douglas-fir Tussock Moth Research and Development Program.

Walking.

Walking is a good exercise for the body. It is also a good exercise for the mind. It can help you to relax and clear your thoughts. It can also help you to feel more energized and focused. Walking is a great way to stay active and healthy.

Running.

Running is another great way to stay active and healthy. It is a high-intensity exercise that can help you burn calories and build muscle. Running can also help you to feel more energized and focused. However, it is important to remember that running can be hard on the joints, so it is important to start slowly and gradually increase your distance and intensity.

Introduction

With increased interest in the Douglas-fir tussock moth, mainly since 1972, both State and Federal agencies have become involved in rearing this insect for a variety of reasons. Reared material has been used to determine the incidence of disease, to evaluate the effectiveness of spray formulations in tests and operational projects, and to determine the occurrence of parasites. In the latter case, the parasite complex was either treated as a group, or the specimens were sent to specialists for determination.^{1/} Obtaining determinations is a time-consuming process, and workers still face the task of comparing the determined specimens with the series of specimens which were not seen by the specialist. This can be a tedious and confusing process when the worker is unfamiliar with the characters used for separating different taxonomic groups.

The following illustrated key and descriptive notes are designed to provide a means for identifying most of the parasites that have been recorded from the tussock moth. Species that have been collected only once or have been collected in a limited geographic area and are rare or uncommon even at that location have been omitted. Notes on morphology and coloration are included so the user can verify his determinations by checking additional characters not included in the key.

Terminology is from Borror and Delong (1960), Townes (1969), and Marsh (1971). The terms "petiole" and "first abdominal segment" are synonymous; petiole is used in the key to reduce wordiness. To facilitate viewing wing venation and number of tarsal segments, it may be advantageous to backlight these structures rather than to shine a light directly on them.

*Key to Douglas-fir Tussock Moth Parasite Adults,
Their Cocoons, and Puparia*

1. Parasite from egg or egg mass	2
Parasite or cocoon from host larva, pupa, or unknown host stage	4
2. Minute (0.3-0.6 mm), yellow-bodied; abdomen broadly joined to thorax; tarsi 3-segmented; postmarginal vein lacking (fig. 1)	24. <i>Trichogramma minutum</i>
Small (1.0-1.6 mm), black- or yellow-bodied; abdomen constricted where it joins thorax; tarsi 4- or 5-segmented; postmarginal vein (pmv) present (figs. 2, 3)	3
3. Black-bodied (1.0-1.2 mm) with 5-segmented tarsi; flagellum of antenna with 10 or 11 segments; compound eyes dark, nearly black; submarginal vein (sm) and marginal vein (mv) continuous (fig. 2).	26. <i>Telenomus californicus</i>

1/ Insect Identification and Beneficial Insect Introduction Institute, ARS-USDA Agricultural Research Center - West, Systematic Entomology Laboratory, Beltsville, MD 20705.

Black- (♀) or yellow-bodied (♂) (1.4-1.6 mm), with 4-segmented tarsi; flagellum 5- or 6-segmented; scape of male much inflated; compound eyes and ocelli red; submarginal vein (sm) and marginal vein (mv) interrupted (fig. 3). 25. *Tetrastichus* sp.

4. Parasite cocoon(s) or puparium (figs. 34, 39, 43-50)	5
Parasite adult	16
5. Dipterous puparium (figs. 34, 39)	6
Hymenopterous cocoon(s) (figs. 43-50)	8
6. Posterior end of puparium with a craterlike cavity; stigmal plates absent (figs. 35, 36)	1. <i>Agria housei</i>
Posterior end of puparium without a craterlike cavity; two stigmal plates present (figs. 40-43)	7
7. Stigmal plates elevated; about as high as protuberance below plates (figs. 39, 40); stigmal slits not on pronounced ridges (fig. 41)	2. <i>Carcelia yalensis</i>
Stigmal plates not elevated; much lower than protuberance; stigmal slits each on a distinct ridge (fig. 42)	3. <i>Exorista mella</i>
8. Cocoon free of substrate ^{2/} or host remains (fig. 43), or attached to substrate by a strand of silk arising from end of cocoon (fig. 44); solitary	9
Cocoon(s) attached to substrate or host remains (figs. 45-50); solitary or gregarious.	11
9. Cocoon an attenuated ellipse (1.7 x 4.6 to 1.9 x 4.7 mm); tan; composed of loosely spun strands, and usually with a long terminal strand (fig. 44)	22. <i>Meteorus tersus</i>
Cocoon ovoid or capsulate (2.6 x 4.8 to 4.6 x 7.3 mm); dark brown to nearly black; sometimes with lighter medial band; composed of tightly spun strands, and without a terminal strand (fig. 43)	10
10. Cocoon ovoid (3.0 x 4.7 to 4.6 x 7.3 mm), sometimes with a medial light band (figs. 43a, 43b)	16. <i>Phobocampe pallipes</i>
Cocoon capsulate (2.6 x 4.8 to 3.2 x 5.7 mm), without a medial light band (fig. 43c)	17. <i>Phobocampe</i> n. sp.
11. Cocoon capsulate (approx. 3.5 x 6.5 mm), white, gray, or tan, and usually with host larval skin covering or attached to cocoon (figs. 45, 46)	12
Cocoon ellipsoid, or smaller, or otherwise without the above combination of characters (figs. 47-50)	13
12. Cocoon (3.6 x 6.8 to 4.2 x 7.5 mm) white; host larval skin covering most of cocoon dorsally (figs. 45c, 46)	18. <i>Hyposoter fugitivus pacificus</i>
Cocoon (2.2 x 5.2 to 3.6 x 7.1 mm) tan to gray, and usually mottled with dark brown or black; host larval skin not	

^{2/} Substrate, as used here, can mean: foliage, twig, or rearing container, e.g., petri dish, vial, etc.

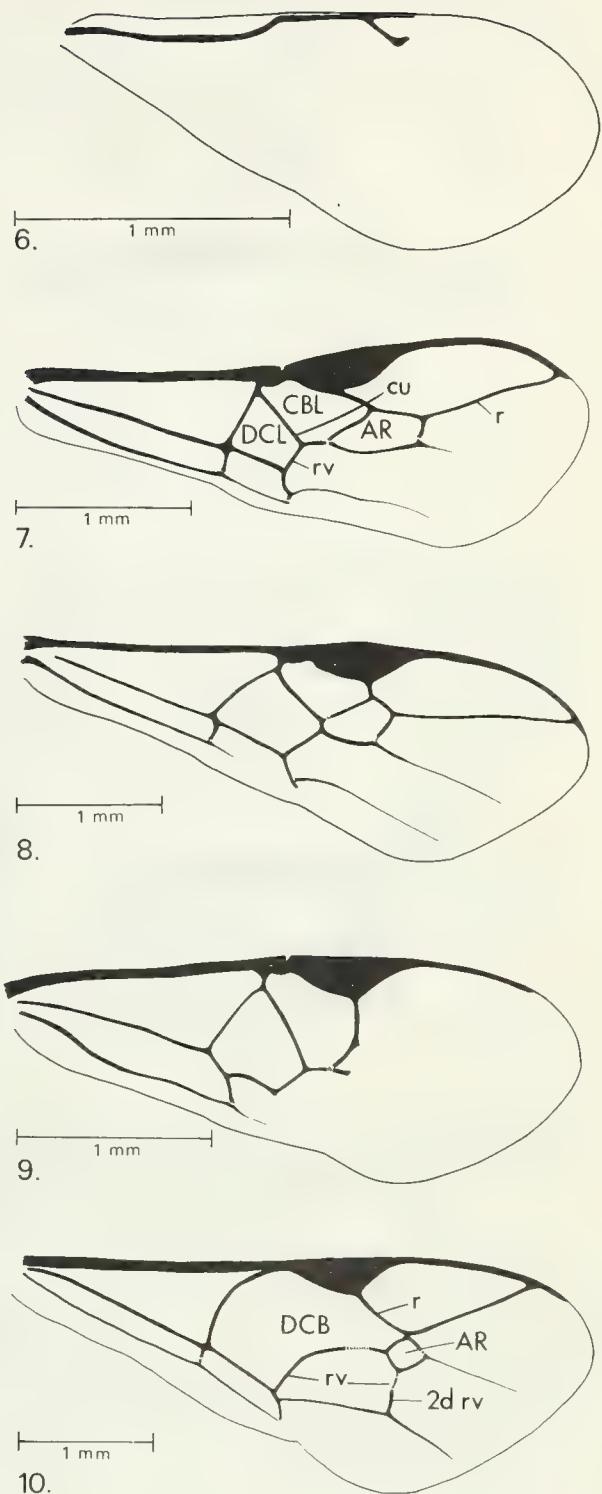
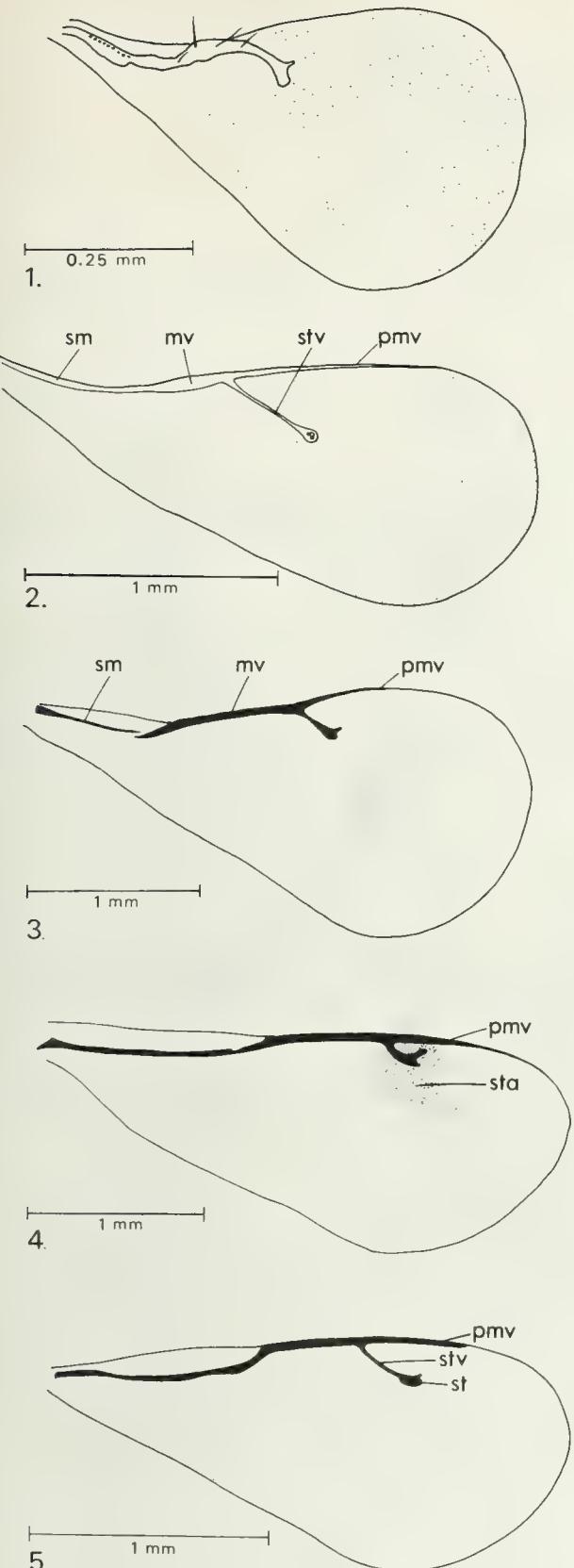
31. Hind femur and tibia reddish-brown.	32
Hind femur reddish-brown; tibia patterned with black and white	33
32. Inner margin of compound eye sharply concave opposite antennal base (fig. 22).	4. <i>Itoplectis viduata</i>
Inner margin of compound eye nearly straight opposite antennal base (fig. 23).	6. <i>Coccygomimus sanguinipes erythropus</i>
33. Hind tibia with extreme base black (fig. 26); mesopleural suture (mps) nearly straight, without an angulation near midlength; propodeal spiracle (pps) elongate (fig. 32). . . .	34
Hind tibia with extreme base white or light colored (figs. 27, 28); mesopleural suture (mps) with an angulation near midlength; propodeal spiracle (pps) round (fig. 33)	35
34. Ovipositor tip curved downward (fig. 31); face of female with pale line along inner margin of eye; face of male mostly white	7. <i>Ephialtes componotus</i>
Ovipositor tip straight; face of both sexes black	5. <i>Itoplectis quadricingulatus</i>
35. Nervellus (nv) intersected by discoidella (dsc) below the middle (fig. 17); hind tibia with submedial pale band interrupted by a dark ventral stripe (fig. 27); ovipositor about as long as abdomen; face and clypeus of male black.	10. <i>Scambus</i> spp.
Nervellus intersected by discoidella above the middle (fig. 18); hind tibia with an encircling submedial pale band (fig. 28); ovipositor about half as long as abdomen; face and clypeus of male white	9. <i>Iseropus stercorator orgyiae</i>
36. Large (9 to 14 mm); head, thorax and abdomen black with white markings; all tibiae and face marked with white.	14. <i>Orgichneumon calcatorius</i>
Smaller (4 to 9 mm); variously colored, not as above	37
37. Areolet (AR) joined to radius (r) by the width of a single vein (figs. 10-12)	38
Areolet (AR) broadly joined to radius (r) (fig. 13); or areolet absent (fig. 14)	42
38. Areolet large, its height approximating length of second recurrent vein (2d rv) (fig. 10); body color yellowish brown.	20. <i>Mesochorus</i> sp.
Areolet much smaller, its height less than half the length of second recurrent vein (figs. 11, 12); head and thorax black, abdomen black or reddish brown.	39
39. Head, thorax, and abdomen black.	40
Head and thorax black, abdomen reddish brown or marked with yellow.	41
40. Hind coxa and femur reddish brown.	18. <i>Hyposoter fugitivus pacificus</i>
Hind coxa black, femur reddish brown.	19. <i>Hyposoter</i> n. sp.

41. Abdomen reddish brown. 16. *Phobocampe pallipes*
Abdomen mostly black with yellowish markings on second and
third tergites 17. *Phobocampe* n. sp.

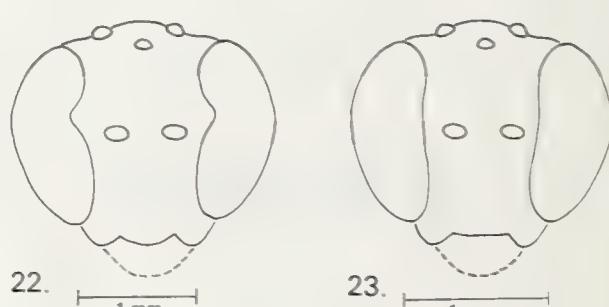
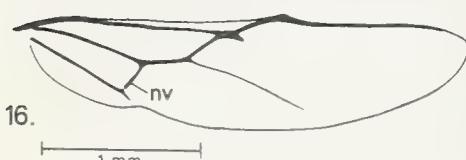
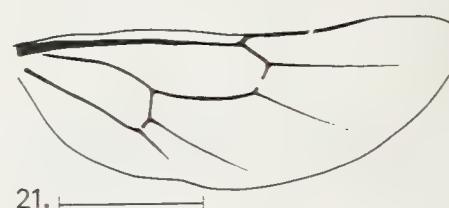
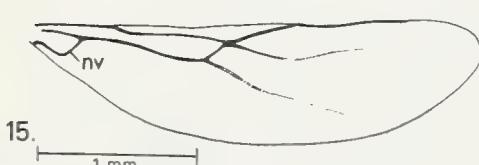
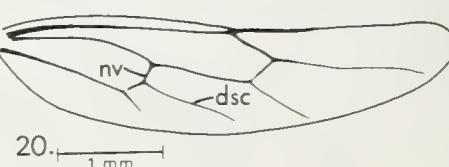
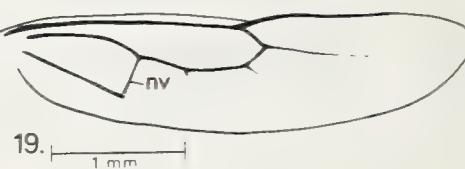
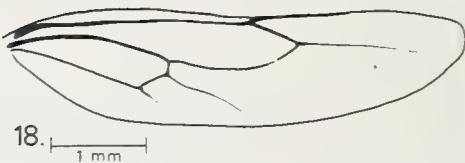
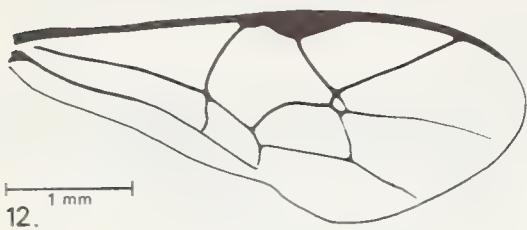
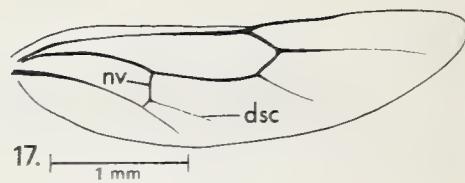
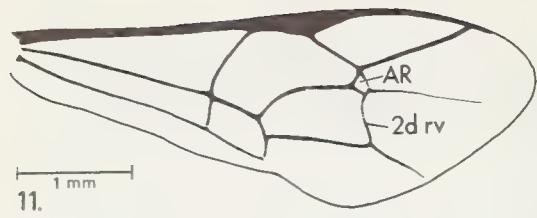
42. Nervellus intercepted by a discoidella (figs. 20, 21). 43
Nervellus not intercepted by a discoidella (fig. 19);
abdominal terga with yellowish markings. 15. *Bathythrix latifrons*

43. Areolet (AR) broadly joined to radius (r) (fig. 13);
nervellus (nv) intercepted by discoidella (dsc) near
the middle (fig. 20). 11. *Gambrus canadensis burkei*
Areolet absent (fig. 14); nervellus intercepted by discoidella
well below middle (fig. 21); forewings sometimes banded. 44

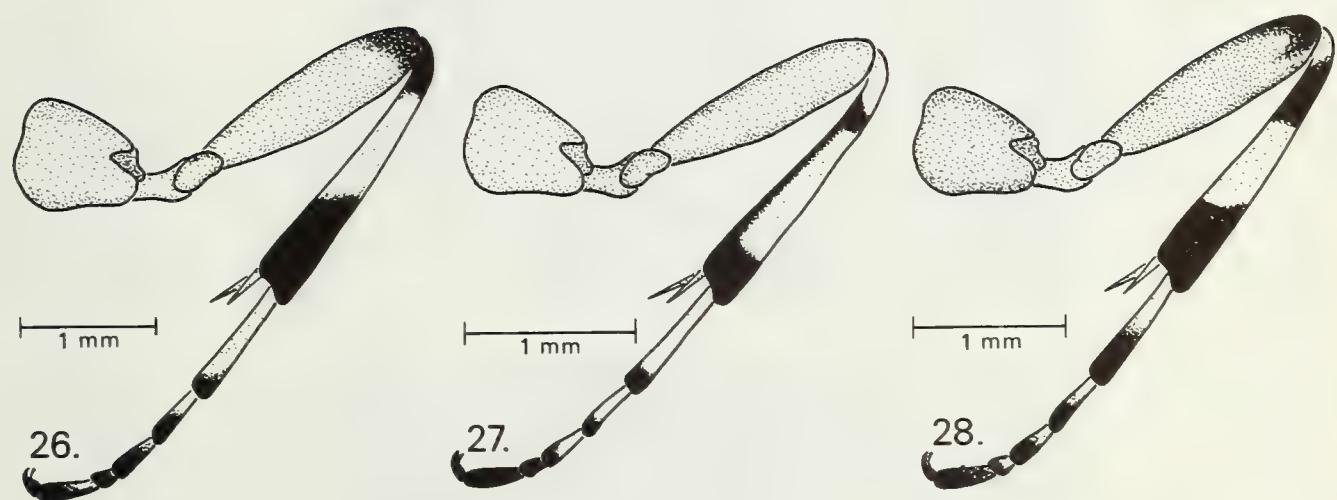
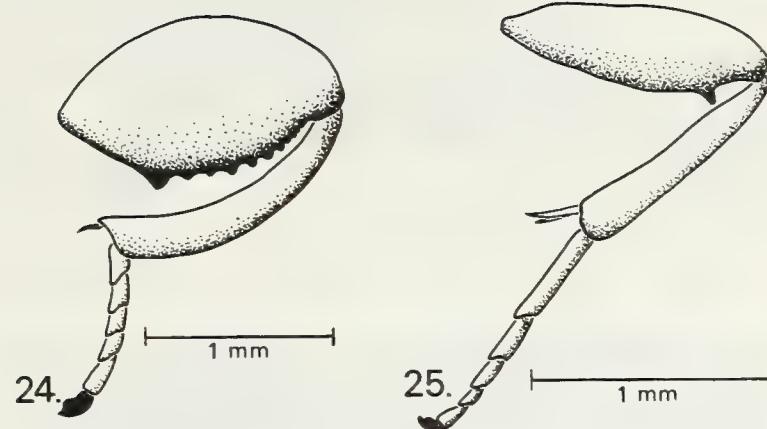
44. Forewing with brown bands (fig. 14). 12. *Gelis tenellus*
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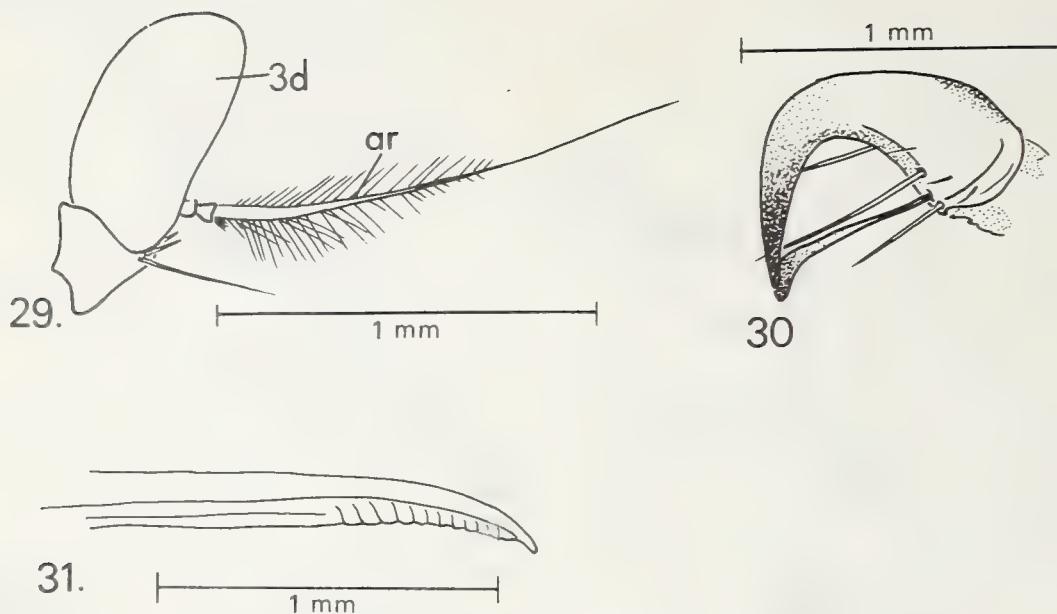
Figures 1-10.--Forewings: 1. *Trichogramma minutum*; 2. *Telenomus californicus*; 3. *Tetrastichus* sp.; 4. *Monodontomerus* sp.; 5. *Hypopteromalus percussor*; 6. *Dibrachys cavus*; 7. *Bracon xanthonotus*; 8. *Meterous tersus*; 9. *Apanteles* sp.; 10. *Mesochorus* sp. AR, areolet; CBL, cubital cell; cu, cubital vein; DCB, discocubital cell; DCL, discoidal cell; mv, marginal vein; pmv, postmarginal vein; r, radial vein; rv, recurrent vein; 2d rv, second recurrent vein; sm, submarginal vein; st, stigma; sta, stigmal area; stv, stigmal vein.



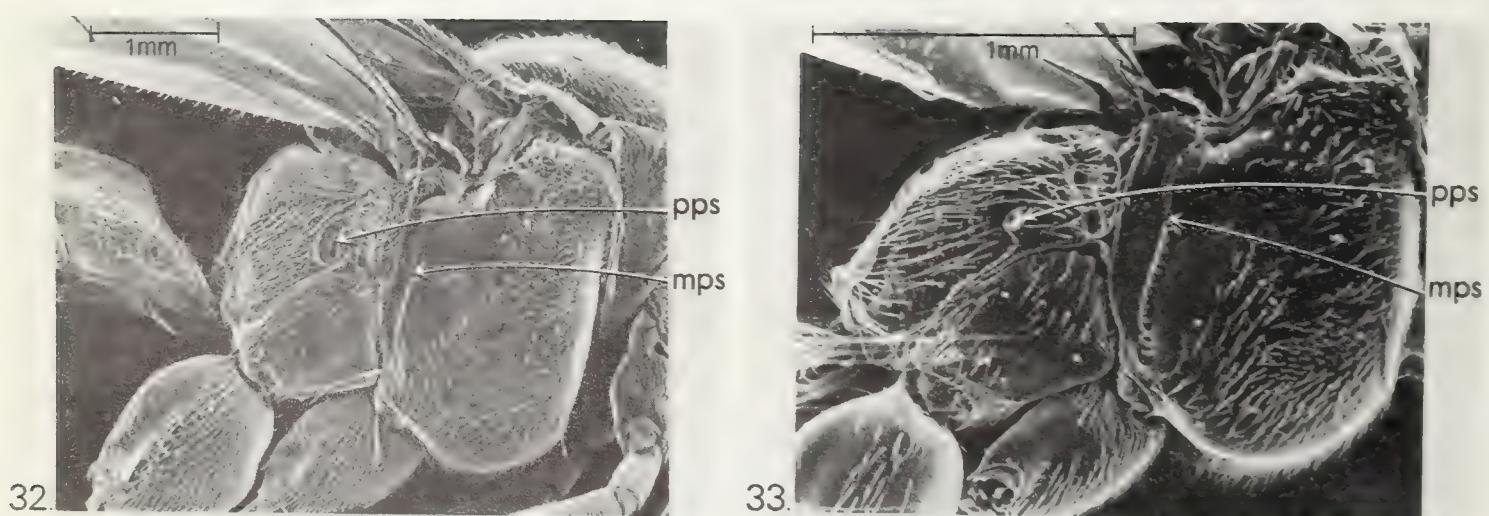
Figures 11-23.--Forewings: 11. *Hyposoter fugitivus pacificus*; 12. *Phobocampe n. sp.*; 13. *Gambrus canadensis*; 14. *Gelis tenellus*. **Hindwings:** 15. *Braccon xanthonotus*; 16. *Meteorus tersus*; 17. *Scambus aplopapus*; 18. *Iseropus stercorator orgyiae*; 19. *Bathythrix latifrons*; 20. *Gambrus canadensis burkei*; 21. *Gelis sp.* **Anterior view of heads:** 22. *Itoplectis quadricingulatus*; 23. *Cocygomimus sanguinipes erythropus*. AR, areolet; dsc, discoideella; nv, nervellus; r, radial vein; 2d rv, second recurrent vein.



Figures 24-28.--Hind legs: 24. *Brachymeria ovata ovata*; 25. *Monodontomerus* sp., 26. *Ephialtes componotus*; 27. *Scambus hispae*; 28. *Iseropus stercorator*.



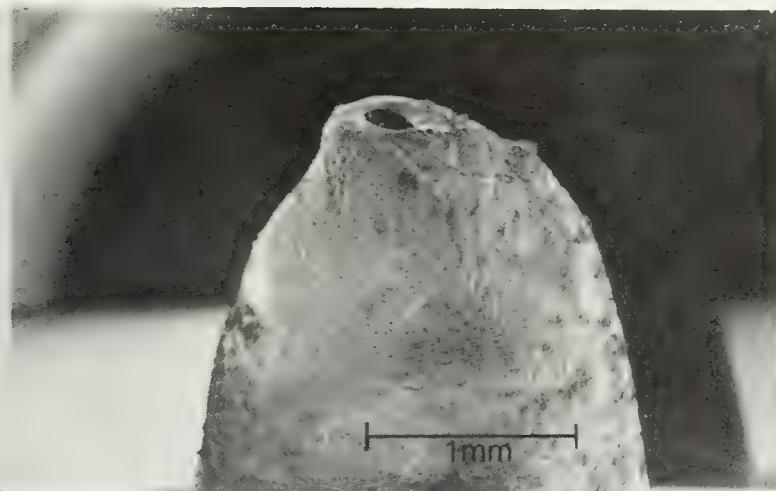
*Figures 29-31.--Antenna: 29. *Agria housei*. Tarsal claw: 30. *Theronia atlantae fulvescens*. Ovipositor tip: 31. *Ephialtes componotus*. ar, arista; 3d, third antennal segment.*



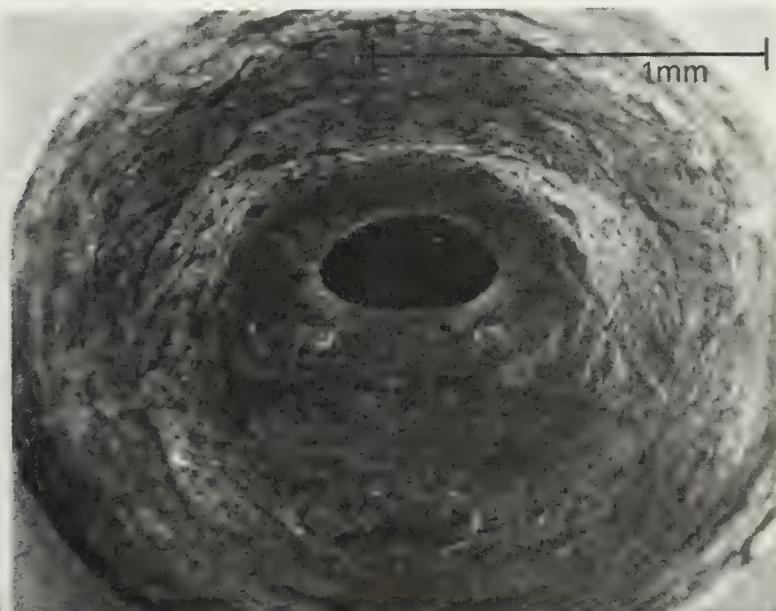
*Figures 32-33.--Mesopleural areas: 32. *Ephialtes componotus*; 33. *Iseropus stercorator orgyiae*. mps, mesopleural suture; pps, propodeal spiracle.*



34.



35.



36.

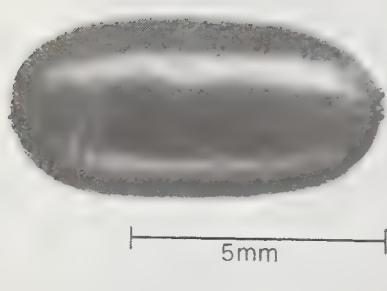
Figures 34-36.--*Agria housei*: 34. Side view of puparium showing natural exit hole and profile of posterior end; 35. Posterolateral view of puparium showing craterlike cavity; 36. Posterior view of puparium.



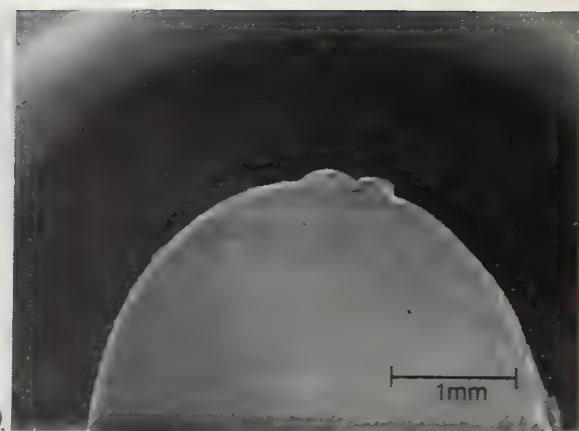
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38.



39.



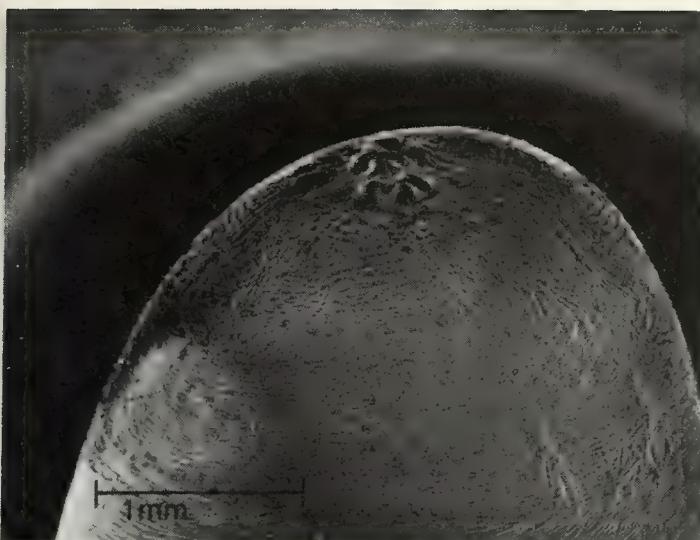
40.



41.

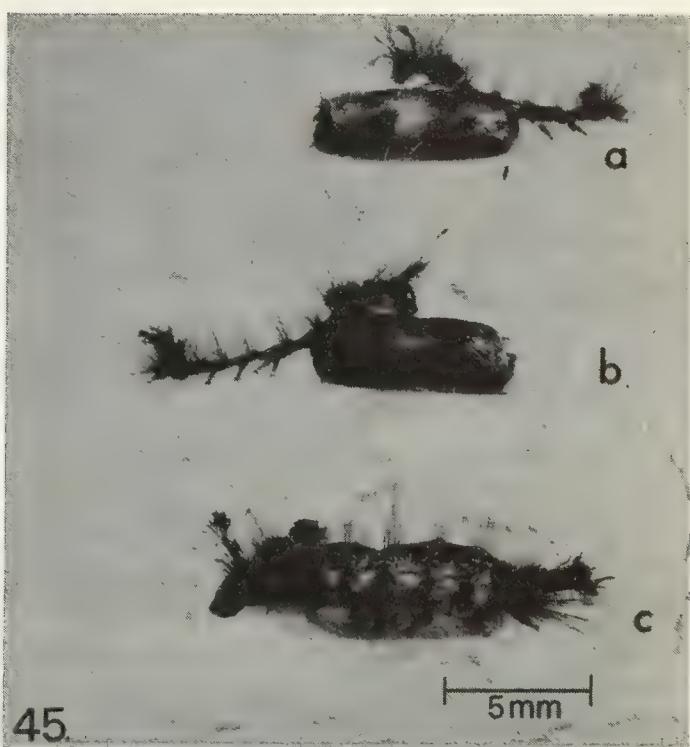
Figures 37-41.--Carcelia yalensis:

37. Side view of adult; 38. Lateroventral view of thorax showing sternopleuron with its two major setae; 39. Side view of unopened puparium; 40. Side view of puparium showing detail of posterior profile; 41. Posterior view of puparium showing detail of spiracular plates.
stp, sternopleuron.



42.

Figure 42.--*Exorista mella*: posterolateral view of puparium showing detail of spiracular plates.



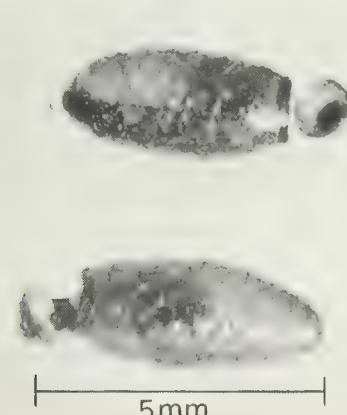
45.

Figure 45.--Cocoons of *Hyposoter* spp., side view: a. and b. *Hyposoter n. sp.*; c. *Hyposoter fugitivus pacificus*.



43.

Figure 43.--Cocoons of *Phobocampe* spp.: a. and b. *Phobocampe pallipes*; c. *Phobocampe n. sp.*



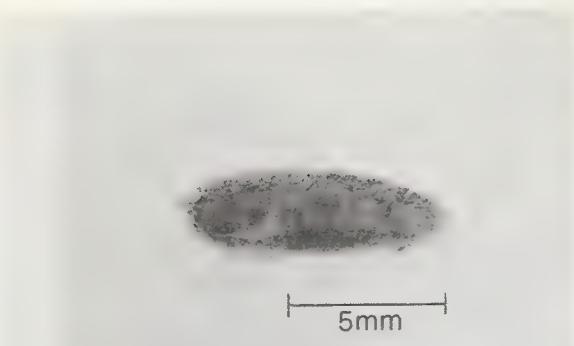
44.

Figure 44.--*Meteorus tersus*: side view of cocoons showing exit hole and terminal filament.



46.

Figure 46.--*Hyposoter fugitivus pacificus*; adult female and cocoon, side views.



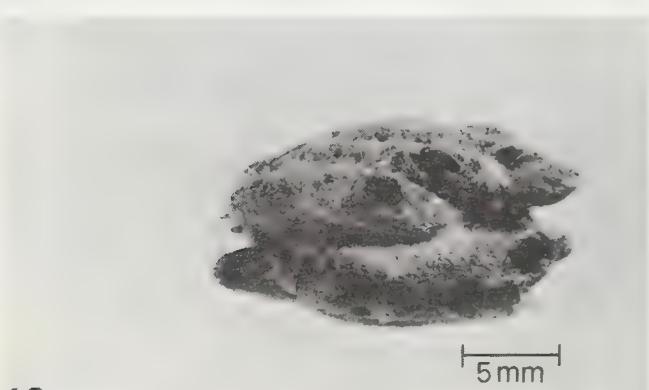
47.

Figure 47.--*Gambrus canadensis*;
cocoon.



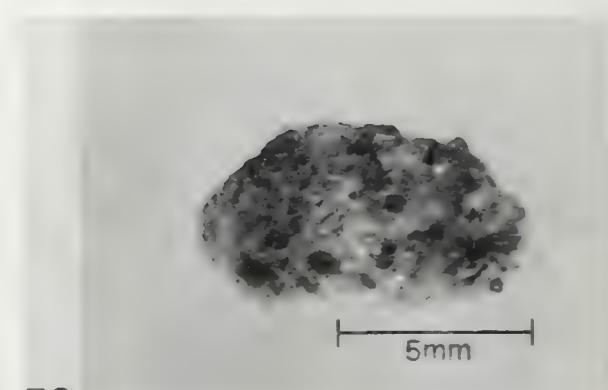
49.

Figure 49.--*Apanteles sp.*; cocoon.



48.

Figure 48.--*Iseropus stercorator orgyiae*;
bundle of several cocoons.



50.

Figure 50.--*Bracon xanthonotus*;
mass of cocoons.



51.



52.

*Figures 51-52.--Phobocampe pallipes;
larva emerging from host skin.*

Additional Diagnostic Features and Notes on Parasites

The following descriptive notes are designed to help the user verify determinations made through the key. In most cases an abbreviated description of the habits of the parasite is also supplied.

DIPTERA

1. *Agria housei* Shewell

(Sarcophagidae)

Figures 29, 34-36

The adult fly is approximately 3.2 to 7.7 mm. Its head, body, and legs are black with gray markings. The predominantly black head has a gena with a distinct gray sheen with changing light angle. The third antennal segment is about half as wide as long; the arista (ar) has setae on basal half or more (fig. 29). There is a poorly developed postscutellum. Posterior margins of the first and second abdominal tergites lack long, prominent setae. Sternopleural area has three prominent setae.

Puparium, 1.9- x 4.8- to 2.6- x 4.7-mm, is reddish brown and slightly darker posteriorly. The main diagnostic character is the prominent craterlike posterior cavity (figs. 34-36). A solitary mature maggot emerges from the late-instar tussock moth larva and drops to the ground. Pupariation and overwintering occur in the duff at a depth of approximately 25 to 40 mm.

2. *Carcelia yalensis* Sellers

(Tachinidae)

Figures 37-41

This fly is approximately 5.0 to 7.9 mm (fig. 37). Its head and body are mostly black with areas of gray and yellowish brown. Gena and frons have a pronounced gray sheen along margin of compound eye; medial area of the frons dark brown. Third antennal segment is 2-1/2 or more times as long as wide; arista bare. Mesoscutellum and lateral areas of the first, second, and third abdominal tergites yellowish brown. There is a well-developed postscutellum. Posterior margins of first, second, and third abdominal tergites each have two or more large prominent setae. Sternopleural area (stp) has two prominent setae (fig. 38). Femora nearly black; tibiae brown to yellowish brown. Tarsal claws much shorter than width of third antennal segment.

Puparium (fig. 39), 3.7- x 6.6- to 4.2- x 7.3-mm, is rich reddish brown to nearly black. Each spiracular plate is borne on a slight protuberance and has three slits (figs. 40, 41).

The host larva is attacked; the mature maggot emerges from the host pupa and drops to the ground where it pupariates and overwinters. In the laboratory, pupariation may take place within the host cocoon near the pupal remains. One or two maggots may successfully develop and emerge from a single host.

Two species of secondary parasites have been reared from *C. yalensis*. A *Pachyneuron*^{3/} species was reared from puparia collected in the duff layer in late spring near La Grande, Oregon, in 1974. This pteromalid is a gregarious parasite that emerged from about 10 percent of the puparia collected. Up to two dozen individuals emerged from a single puparium. Another species, *Mastrus argeae* (Vier.),^{4/} represented by a single individual, emerged from a puparium in the same collection.

3. *Exorista mella* (Walker)

(Tachinidae)

Figure 42

Adult size is approximately 9.0 to 10.1 mm. The head has a distinct gray sheen; gena and frons bronze; medial area of frons dark brown to black. Third antennal segment is about 2-1/2 times as long as wide; arista bare. Thorax, abdomen, and legs are black with gray markings. Mesoscutellum and lateral area of second abdominal tergite have a brown tinge. There is a well-developed postscutellum. Posterior margins of first, second, and third abdominal tergites each with two or more stout setae. Sternopleural area with three prominent setae. Tarsal claws long and slender; about as long as width of third antennal segment.

Puparium is approximately 4.0 x 7.0 mm. Stigmal plates not raised above surface of puparium; the three slits are each borne on a distinct ridge (fig. 42).

The tussock moth larva is attacked, and the mature maggot emerges from the dead host pupa to pupariate and overwinter in the duff.

HYMENOPTERA

4. *Itoplectis viduata* (Gravenhorst)

(Ichneumonidae: Ephialtinae)

The body may be 6.5 to 12.9 mm; and the ovipositor may add another 2.4 to 4.2 mm to that length. The head, thorax, abdomen, and coxae are black. The black tegula is sometimes pale anteriorly. Legs are mostly dark reddish brown. Ovipositor straight; its tip is not bent downward as in *Ephialtes* species. Inner margin of the compound eye has a rounded notch opposite the antennal base as in figure 22.

According to Dahlsten et al. (1977) this species appears to be capable of ovipositing in prespinning and cocooned larvae as well as pupae. Emergence is from the host pupa.

^{3/} Hymenoptera: Pteromalidae.

^{4/} Hymenoptera: Ichneumonidae.

5. *Itoplectis quadricingulatus* (Provancher)

(Ichneumonidae: Ephialtinae)

Figure 22

Body length is approximately 5.8 to 8.9 mm; ovipositor 1.5 to 2.0 mm in addition. The head, thorax, and abdomen are black. The black tegula is pale anteriorly. Pro- and mesothoracic legs are mostly reddish to pale. Metathoracic leg with coxa reddish, or sometimes nearly black; femur is reddish. Hind tibia is conspicuously banded with black and white. It is black basally and apically, with an intervening encircling white band. Inner margin of the compound eye has a notch opposite the antennal base (fig. 22).

Host is normally attacked as a pupa within the cocoon and the adult parasite emerges from the host pupa in the spring. There are also two records of *I. quadricingulatus* acting as a secondary parasite emerging from cocoons of *Hyposoter* n. sp.

6. *Coccygomimus sanguinipes erythropus* (Viereck)

(Ichneumonidae: Ephialtinae)

Figure 23

Adults are 7.3 to 11.3 mm in length; the ovipositor is 3.0 to 3.2 mm. The head, thorax, and abdomen are black. The tegula is usually black, but partly pale in males. Legs of female are uniformly reddish brown. Legs of male similar, except that the front coxa may be black. The hind tarsus and apex of the hind tibia are usually black. The inner margin of the compound eye lacks a prominent indentation opposite the antennal base (fig. 23).

Host is normally attacked as a pupa within the cocoon. Emergence from the host pupa occurs in the spring.

7. *Ephialtes componotus* (Davis)

(Ichneumonidae: Ephialtinae)

Figure 31

The body length is approximately 7.4 to 13.9 mm; ovipositor 1.6 to 2.2 mm in addition. The head, thorax, and abdomen are mostly black. Face of the male is largely white; face of the female marked with white along inner margin of the compound eye. The mesonotum is marked with white; tegula white. Coxae, femora, and front and middle tibiae nearly white to light reddish brown. Hind tibia black basally and apically, with an encircling white band near basal third (fig. 26). Ovipositor is about as long as hind tibia and curves downward abruptly near its tip (fig. 31).

Oviposition occurs into the cocooned host pupa within which the developing parasite overwinters; emergence is in the spring.

8. *Theronia atalantae fulvescens* (Cresson)

(Ichneumonidae: Ephialtinae)

Figure 30

Body length is 8.5 to 11.8 mm; ovipositor approximately 2.7 to 3.7 mm. The body and legs are light yellowish brown, with darker markings on mesothorax and metapleurum. Mandibular tips, ovipositor, and ovipositor sheath are dark. Each of the tarsal claws has a specialized long seta extending from base to tip (fig. 30); the arolium is large and conspicuous.

The cocooned host pupa is parasitized, and solitary emergence occurs in the spring.

9. *Iseropus stercorator orgyiae* (Ashmead)

(Ichneumonidae: Pimplinae)

Figures 18, 28, 48

Size is approximately 5.5 to 9.2 mm; ovipositor 2.7 to 3.6 mm. The head, thorax, and abdomen of the female are black; male similar, except that the face, clypeus, and anterior portions of scape and flagellum are white. Tegula and hind corner of pronotum white. Front and middle legs, and hind coxa and femur are nearly white to reddish brown. Hind tibia pale or white basally and near its basal third, and dark or black subbasally and apically. The overall impression is a banded effect of the hind tibia, with the base light colored. Hind tarsal segments are white or pale brown basally; black or nearly so, apically (fig. 28). Nervellus in hind wing is intersected by the discoidella above the middle (fig. 18).

This is a solitary or gregarious, primary parasite which feeds externally in the host's cocoon.

Parasite cocoons may be formed within the host cocoon, but under laboratory conditions the parasite cocoons may be found outside the host cocoon. When several cocoons are present they may be formed side by side in a single mass or bundle of as many as a dozen cocoons (fig. 48). The bundle of cocoons shown measures approximately 10 x 18 mm.

10. *Scambus* spp.

(Ichneumonidae: Ephialtinae)

Figures 17, 27

Adult size is approximately 7 to 13 mm. Head, thorax, and abdomen black, except for the hind corner of the pronotum near the tegula. The anterior surface of the antennal scape and/or the pedicel in the male are pale to nearly white. Hind tibia and tarsus patterned with black and white. The tibia is pale basally and medially, and black apically and subbasally. Most of the hind tarsal segments are pale to white, and dark or black apically (fig. 27). Ovipositor about as long as abdomen. Nervellus in hind wing is intersected by the discoidella slightly or well

below the middle (fig. 17).

The individuals representing this genus all emerged from hosts collected as pupae.

11. *Gambrus canadensis burkei* (Viereck)

(Ichneumonidae: Gelinae)

Figures 13, 20, 47

Size is approximately 6.9 to 9.1 mm. Head, thorax, and base of first abdominal segment black; terminal abdominal segments are dark brown to black. The major portion of first, second, and third abdominal segments and the legs are reddish brown. Ovipositor 2.4 to 2.9 mm; much longer than the depth of the abdomen distally. The ovipositor lacks a dorsal notch near its tip. The forewing (fig. 13) is characterized by a rather large sessile areolet; hindwing as in figure 20.

This species is a solitary or gregarious primary parasite which attacks host larvae and emerges from cocooned ultimate instar larvae or pupae. The parasite cocoons are normally formed within the host cocoon (Dahlsten et al. 1977). Individual parasite cocoons vary in size from 3.8 x 10.6 mm to 4.4 x 13.1 mm. The cocoon is gray brown, with its outer surface composed of loose fibers (fig. 47).

12. *Gelis tenellus* (Say)

(Ichneumonidae: Gelinae)

Figure 14

Body length is approximately 5 mm. The entire insect is reddish brown with darker areas on the propodeum and terminal abdominal segments. The ovipositor is as long, or slightly longer than the hind tibia. The areolet is absent in the forewing, which is conspicuously marked with two dark bands (fig. 14).

This species normally operates as a secondary parasite which attacks and emerges from the cocoon of *Hyposoter* species that parasitize the tussock moth. Although it has not been recorded, it is likely that this species could also attack the cocoons of *Phobocampe* species.

13. *Gelis* spp.

(Ichneumonidae: Gelinae)

Figure 21

Two species of *Gelis*, each represented by a single specimen, have been reared in connection with tussock moth studies. Both species emerged from cocoons of *Phobocampe pallipes*.

The general body color of the two species is black, with reddish brown abdomen and legs.

14. *Orgichneumon calcatorius* (Thunberg)

(Ichneumonidae: Gelinae)

Large (9- to 14-mm) black ichneumonids with prominent white markings on face and/or inner and outer margins of compound eye, the several medial antennal segments of female, pronotum, scutellum, apex of first abdominal segment, tibiae, and on most tarsal segments. Ovipositor very short, not visible, or barely evident at tip of abdomen. Nervellus in hindwing intersected by the discoideilla below the middle.

The adult parasite emerges from the host pupa. All the representatives of *O. calcatorius* that I have examined have emerged from hosts collected as pupae in their cocoons. Females of some genera closely related to *Orgichneumon* emerge from their host in the fall and hibernate as adults (Heinrich 1960); this has not been shown for *O. calcatorius*, but it may occur.

15. *Bathythrix latifrons* (Cushman)

(Ichneumonidae: Gelinae)

Figure 19

Body length is about 5 mm; ovipositor about as long as front femur. Head and thorax black; first abdominal tergite dark, nearly black, with yellow on posterior portion. Each of the remaining abdominal terga brown anteriorly, and grading into posterior yellow band of varying width. Front and middle legs pale yellow to light brown. Hind legs darker brown. Hindwing lacks a discoideilla intersecting the nervellus (fig. 19).

This is a secondary parasite which oviposits in and ultimately emerges from the cocoon of *Hyposoter* n. sp.

16. *Phobocampe pallipes* (Provancher)

(Ichneumonidae: Porizontinae)

Figures 43a, 43b, 51, 52

This is a medium-sized parasite, about 5.1- to 7.4-mm, with black head and thorax. The mandibles, palps, scape, pedicel, and the tegula are pale yellowish white. The abdomen, legs, and sometimes the distal third of the antennal flagellum are reddish brown. The tarsi bear small pectinate claws, and the short ovipositor, when exserted, has a subapical dorsal notch. In the hindwing the nervellus is not intersected by a discoideilla.

This species, a solitary primary internal larval parasite, is one of the most common parasites attacking the tussock moth. After the mature parasite larva has completed its development within the host larva, it emerges from the host (figs. 51, 52) and spins its cocoon. Spinning may occur in close proximity to the host or in the duff on the ground. Ultimately the cocoon falls to the ground where overwintering normally occurs. Cocoons are ovoid, 3.1- x 4.7- to 4.6- x 7.3-mm, usually very dark in color, and commonly have a light circumferential band (figs. 43a, 43b). Newly formed cocoons sometimes move, wiggle, or "jump" when they

are on a firm surface. This is caused by sudden movements of the parasite larva within the cocoon.

17. *Phobocampe* n. sp.

(Ichneumonidae: Porizontinae)

Figure 43c

This species is somewhat smaller than *P. pallipes*, about 4.5 to 5.2 mm. The head, flagellum of antenna, thorax, and most of the abdomen are black. The mandibles, palps, scape, pedicel, tegula, parts of the second and third abdominal tergites, and the lateral portions of the remaining tergites are yellow. The front and middle legs vary from pale yellow to light reddish brown, while the hind leg has a brown or nearly black coxa, a brown femur and distal portion of tibia, and the remainder of tibia and tarsus pale to light brown. The ovipositor is short, usually not extended beyond end of abdomen, and bears a subapical dorsal notch. The tarsi bear small pectinate claws.

This is a very common primary internal larval parasite which emerges from the dead host larva. It forms a capsule-shaped cocoon about 2.6 x 4.8 to 3.2 x 5.7 mm (fig. 43c), which is somewhat smaller than the cocoon of *Phobocampe pallipes* (figs. 43a, 43b). The cocoon is very dark gray brown to nearly black, sometimes having a slight hint of a light band.

18. *Hyposoter fugitivus pacificus* Cushman

(Ichneumonidae: Porizontinae)

Figures 11, 45c, 46

This is a medium-sized species, 5.9- to 7.8-mm, with a very short ovipositor that does not extend much beyond the end of the abdomen (fig. 46). The ovipositor has a subapical dorsal notch. Head, thorax, and abdomen are black. The hind corner of the pronotum near the tegula, and the tegula itself are white. The front and middle legs are light colored to reddish. One of the best diagnostic features separating this species from *Hyposoter* n. sp. is the coloring of the hind leg. In particular, the hind coxa, trochanters, and femur are reddish brown, while the tibia is dark subbasally and apically, and nearly white basally and medially. The hind tarsus is black except for the white base on the first segment, the tarsal claws are small and pectinate.

The cocoon is similar in shape to that of the other *Hyposoter* species but differs in its coloration and the disposition of the host's larval remains. Probably the most striking aspect is the way the host larval skin covers the entire dorsal aspect of the cocoon which is nearly white (figs. 45c, 46). The cocoon is 3.6 x 6.8 to 4.2 x 7.5 mm. somewhat larger than that of *Hyposoter* n. sp.

This species is a solitary internal primary parasite that attacks and emerges from the larva. The winter is passed in the cocoon stage and emergence occurs in the spring. *Hyposoter* species usually attack exposed larvae and have a rather wide range of hosts. It is possible that they utilize alternate hosts occurring in the same habitats as the tussock moth.

19. *Hyposoter* n. sp.

(Ichneumonidae: Porizontinae)

Figures 45a, 45b

This species is a very common parasite of the tussock moth. It is a smaller species than *H. fugitivus pacificus*, about 4.5 to 6.5 mm. The head, thorax, and abdomen are black, and the hind corner of the pronotum lacks the white marking evident in *H. f. pacificus*. The tegula, mandibles, and palps are white. Though the abdomen is generally black, the second and third abdominal tergites are sometimes infused with brown. The front leg is light colored, but the coxa is sometimes darker. The middle coxa is black, and the remainder of the leg is light colored. One of the features that readily distinguishes this species from *H. f. pacificus* is that the hind coxa, and commonly the first trochanter, are black. The femur is reddish brown, while the tibia exhibits a black and white pattern; black subbasally and apically, and light or white basally and medially. The hind tarsus is mostly black, but the basal segment of the middle tarsus is light colored. The ovipositor and tarsal claws are similar to *H. f. pacificus*.

Though slightly smaller and patterned differently, the cocoon is similar to *H. f. pacificus*. Its size is about 2.2 x 5.2 to 3.6 x 7.1 mm. The background color of the cocoon is tan to gray, and normally there is a distinct mottling of dark brown or black in a random pattern. In undisturbed specimens, the host larval skin is attached near one end on the dorsal surface of the cocoon. Usually, the skin appears to be attached at the larval prolegs (figs. 45a, 45b).

The parasite attacks and emerges from the larva; winter is passed in the cocoon stage. Emergence takes place about the time of tussock moth egg hatch and adults can be seen in flight through July (Mason 1976). Dahlsten et al. (1977) observed two peaks in *Hyposoter* species emergence from field-collected, laboratory-reared material. They speculated that the emergence pattern of *H. f. pacificus* was different from *Hyposoter* n. sp., suggesting biological differences between these two species utilizing the same host.

20. *Mesochorus* sp.

(Ichneumonidae: Mesochorinae)

Figure 10

This is a secondary parasite emerging from cocoons of *Phobocampe* n. sp. It is a rather small ichneumonid of from 4.0 to 6.5 mm, but usually at the smaller end of that range in size. The head, thorax, and legs are light yellowish brown to somewhat lighter; the hind tibia is darker apically. The first and second abdominal tergites are dark brown; the third tergite is lighter brown to yellowish; and the remaining distal tergites vary from brown to yellowish. The abdomen of the male terminates in two thin styli, and that of the female in a short ovipositor protected by a broad sheath. The antenna is longer than the forewing length. A conspicuous diamond-shaped areolet (AR) is present in the forewing (fig. 10), and the hindwing is characterized by its lack of a discoidella intersecting the nervellus.

21. *Apanteles* spp.

(Braconidae: Microgasterinae)

Figures 9, 49

These rather small, 2.4- to 3.4-mm, species occur sporadically as internal solitary primary parasites reared from late-instar larvae.

The microgasterines are characterized by lack of a radial vein (fig. 9), by an abdomen broadly joined to the thorax, and by a rather small, heavily sculptured abdomen. One of the more common of the two *Apanteles* species is black bodied with yellowish-brown legs, and palps. The antenna has 18 segments. The ovipositor is short and barely extends beyond the abdomen.

An ellipsoid cocoon (1.5- x 3.6- to 1.9- x 5.6-mm) composed of loosely spun fibers over a more dense capsule (fig. 49) is formed some distance from the host late larval remains. Although the cocoon is normally white, it sometimes has a tinge of green.

22. *Meteorus tersus* Muesebeck

(Braconidae: Euphorinae)

Figures 16, 44

Body size is approximately 3.6 to 5.0 mm; ovipositor 0.8 to 0.9 mm. The general body color is yellowish brown with dark-brown markings in the ocellar area, the occiput, mesonotum, propodeum, and first and posterior abdominal segments. Sculpturing, or lack of it, is striking, as on the first abdominal tergite which is striate posteriorly, and on the second and third abdominal tergites which are fused and shiny. The 33-segmented antenna is longer than the body.

This species is a solitary internal larval parasite. It emerges as a mature larva from the host larval skin and spins a cocoon that is roughly spindle shaped with blunt ends, 1.7 x 4.6 to 1.9 x 4.7 mm (fig. 44). The terminal strand of silk is characteristic; and under natural conditions, the cocoon will be found suspended from the foliage by this thread. In the spring the adult parasite emerges from the cocoon by cutting around the cocoon and pushing the cap back.

23. *Bracon xanthonotus* Ashmead

(Braconidae: Blacinae)

Figures 7, 50

This species is a rather common parasite in California,^{5/} though it appears less commonly elsewhere in the range of tussock moth. It is a

^{5/} Based in part on examination of museum specimens housed at Forestry Sciences Laboratory, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oregon; a letter to Dr. C. G. Thompson from Dr. R. Ryan, July 28, 1971, on file at same location; and Dahlsten et al. (1977).

gregarious primary parasite emerging from cocooned ultimate-instar host larvae. Cocoons of the parasites are formed in a clump, attached or close to the host larval remains. The mass of cocoons pictured in figure 50 measures 5 x 9 mm. Adults are 2.6 to 3.2 mm and are dark bodied with yellowish-brown markings. Markings on the head occur along the eye margins and at the base of the antenna, gena, and mandibles. Variable yellow markings occur on the mesonotum, second abdominal segment, and the legs. A deeply emarginate clypeus gives the impression of a pit above the mandibles. Antennae of females have 24 segments and antennae of males, 28. The ovipositor is shorter than the hind femur (0.6 to 0.7 mm). Forewing has a large prominent areolet (AR) (Fig. 7).

Hypopteromalus percussor acts as a secondary parasite attacking cocoons of *B. xanthonotus* (Dahlsten et al. 1977) (see section 27).

24. *Trichogramma minutum* Riley

(Chalcidoidea: Trichogrammatidae)

Figure 1

These are minute (0.3 to 0.6 mm), yellow-bodied insects with uniformly yellow legs. In males, the abdomen and thorax are partly brownish. The compound eyes and ocelli of both sexes are bright red. Males are further distinguished by prominent antennal setae, some of which exceed the length of individual antennal segments. The antenna of the female has an enlarged terminal segment. The arrangement of setae in the forewings is in distinct rows (fig. 1). In the hindwing the length of the marginal fringe exceeds the width of the wing. The tarsi have 3 segments.

The species is a very common solitary or gregarious parasite emerging from the tussock moth egg. Laboratory emergence from field collected eggs can occur without cold shock.

According to Dahlsten (personal communication), *Trichogramma californica* Nagarkatti and Nagaraja is as common as *T. minutum* in California. He states that *T. californica* displays more dark patterning than *T. minutum*; females of *T. minutum* are uniformly yellow, while females of *T. californica* have a dark abdomen.

25. *Tetrastichus* spp.

(Chalcidoidea: Eulophidae)

Figure 3

Two species of *Tetrastichus* have been reared from the tussock moth; one from the egg, another from small larvae.

The *Tetrastichus* species reared from the egg exhibits striking sexual dimorphism. Both sexes are small, 1.4 to 1.6 mm, and have red compound eyes. The general body color of the male is yellow, with the dorsum of thorax and abdomen infused with brown. The female is black, with brown or pale-colored legs and antennae. The elbowed antenna has 5 flagellar segments in the female and 6 in the male. Also, the scape on the male's

antenna is enlarged; larger in diameter than the femora. In the forewing the stigmal vein is less than half as long as the antennal scape. This egg parasite has appeared commonly in egg masses collected in New Mexico.^{6/} Single and double emergences occur from individual eggs.

Another species of *Tetrastichus* was reared from late first- or second-instar larvae by Dahlsten et al. (1977), but specimens are unavailable for study.

26. *Telenomus californicus* Ashmead

(Serphoidea: Scelionidae)

Figure 2

This species is very common and has been the dominant egg parasite in some collection locations (Mason 1976, Dahlsten et al. 1977).

The adult wasps are small (1.0 to 1.2 mm), about intermediate in size between *Trichogramma minutum* and the egg-attacking *Tetrastichus*. The body and legs are black, except for some lighter coloration on distal portions of the legs. In the male the antennal flagellum has 11 segments and is filiform; in the female it has 10 segments and is more capitate. The scape is about as long as the width of the vertex. The vertex is rather wide, about 1-1/2 times as wide as the height of the compound eye. The abdomen is constricted where it joins the thorax, and the abdominal tergites are smooth with rounded lateral margins. Setae on the forewing are evenly distributed, and the stigmal vein (stv) (fig. 2) is as long or longer than the antennal scape. The marginal fringe on the hindwings is much shorter than the width of the wing. The tarsi have 5 segments.

27. *Hypopteromalus percussor* Girault

(Chalcidoidea: Pteromalidae)

Figure 5

According to Dahlsten et al. (1977), this species is a secondary parasite of *Bracon xanthonotus*. *H. percussor* emerges from cocoons of that gregarious species (see section 23).

These chalcidoids are 1.8 to 3.1 mm in length and are bright metallic green or blue. The abdomen of the male is dark brown to slightly metallic with a yellow band at the second tergite. The legs are mostly yellow, with the femora darker brown in the female.

^{6/} Personal communication with Dr. D. Jennings, formerly of the Rocky Mountain Forest and Range Experiment Station, Albuquerque, New Mexico.

28. *Dibrachys cavus* (Walk.)

(Chalcidoidea: Pteromalidae)

Figure 6

This is an uncommon parasite which emerges from the tussock moth cocoon (Bedard 1938). Based on the broad host range of this species (Peck 1963), it can likely operate as either a primary or secondary parasite of the tussock moth.

It is a rather small (1.6- to 2.6-mm) wasp with a dark metallic head and thorax and a shiny, dark-brown to nearly black abdomen. The abdomen of the male is light brown with a yellow band. The legs of both sexes are yellowish brown with the coxae darker. Forewing has a very short postmarginal vein (pmv, fig. 6).

29. *Monodontomerus* spp.

(Chalcidoidea: Torymidae)

Figures 4, 25

Two species, *M. dentipes* (Dalman)^{7/} ^{8/} (Bedard 1938) and *M. saltuosus* Grissell (Dahlsten et al. 1977), have been recorded as primary and secondary parasites, respectively, of tussock moth. The following description will distinguish *Monodontomerus* from the other genera mentioned herein.

These are small species, 2.9- to 3.6-mm, with ovipositors as long as 1.2 mm. The head, thorax, abdomen, coxae, and femora dark metallic green; the front and middle femora sometimes lacking the metallic luster. The tarsi and tibiae tend to brownish or yellowish brown. The most striking distinguishing characters are the enlarged hind coxa and the presence of the tooth near the distal end, on the ventral aspect of the hind femur (fig. 25). There is also an enlarged brown area near the stigma in the forewing (fig. 4). Females have a long prominent ovipositor extending beyond the end of the abdomen.

30. *Brachymeria ovata ovata* (Say)

(Chalcidoidea: Chalcididae)

Figure 24

This species (4.9- to 6.1-mm) is easily identified by its black and yellow patterning and by the shape of the hind leg. The general body color is black with yellow on the tegula, the distal end of the femora, both ends of the tibiae, and the tarsi. Punctations on the thorax are very

^{7/} Jennings, D. T. 1975. Natural enemies of the Douglas-fir tussock moth in the Central Rocky Mountains and the Southwest. Unpublished progress report on file at Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

^{8/} Yasinski, F. M., and D. L. Wheeler. 1962. Douglas-fir tussock moth. A progress report. 7 p. Unpublished report on file at Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

coarse, contrasting with the second abdominal tergite which is smooth and shiny. The petiole is so foreshortened as to appear to be absent. The hind femur is greatly enlarged and has a row of prominent teeth on its lower surface where it fits against the curved tibia (fig. 24). This species emerges from tussock moth hosts collected as cocoons (Dahlsten et al. 1977; also see footnote 8).

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Pacific Northwest Forest and Range Experimental
Station, Portland, Oregon.

A key for the identification of egg, larval, and pupal
parasites of the Douglas-fir tussock moth is supplied.
Determinations are based on features of adult parasites,
their cocoons, or puparia. Notes on additional diagnostic
characters and biologies are also given.

KEYWORDS: Parasite key, parasites (insect), Douglas-fir
tussock moth, *Orgyia pseudotsugata*.

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A key for the identification of egg, larval, and pupal
parasites of the Douglas-fir tussock moth is supplied.
Determinations are based on features of adult parasites,
their cocoons, or puparia. Notes on additional diagnostic
characters and biologies are also given.

KEYWORDS: Parasite key, parasites (insect), Douglas-fir
tussock moth, *Orgyia pseudotsugata*.



The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research will be made available promptly. Project headquarters are at:

Fairbanks, Alaska	Portland, Oregon
Juneau, Alaska	Olympia, Washington
Bend, Oregon	Seattle, Washington
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The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

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